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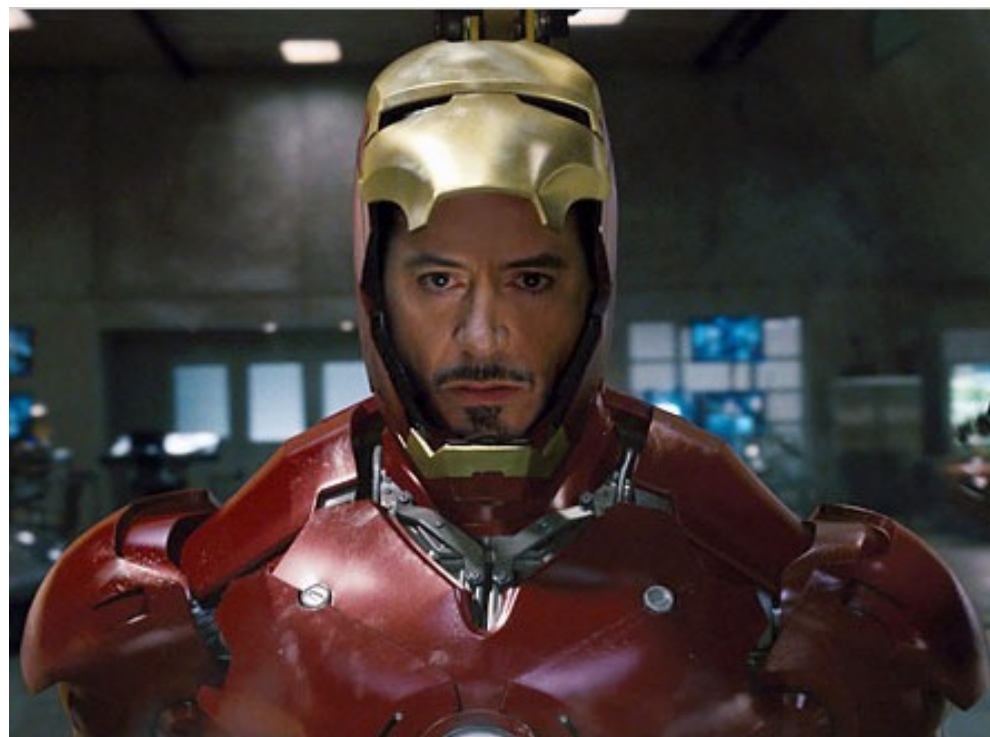
Ethics of Emerging Technologies

Soldier Enhancement

University of Notre Dame

Spring 2013





US ARMY Future Soldier 2030

Future Soldier 2030 is a concept of how the future Soldier might be equipped. The future Soldier shall be tailored with design considerations for each technology area name below with special emphasis on cognitive performance to improve Soldier effectiveness and an increase in operational tempo. The Future Soldier will be capable of full spectrum operations with role-based capabilities per TRADOCs FM 3.0 and emerging FM 3.1. There are seven major areas within Future Soldier:

1. Human Performance & Training
2. Soldier Protection
3. Lethality
4. Mobility and Logistics
5. Soldier Network
6. Soldier Sensors
7. Soldier Power & Energy



ERGOGENICS

- Integrated nanotechnology based exoskeleton – improved speed, strength, and agility
- Cognitive enhancers (nutritional, nootropic or other smart drugs)
- Physical enhancers (nutritional, pharmaceutical)
- Neural prosthetics (controversial now, but perhaps ubiquitous in 2030)

MENTAL & PHYSICAL STATUS MONITORING

- Behavioral
- Neural
- Internal (fNIR sensing of blood oxygenation, glucose)
- Linked to individual predictive model of Soldier performance as a function of state variables

Plan

- What is enhancement?
- Types of enhancement - general
- Advantages
- Issues

What is it?

- Improving mind, body, ability
- Natural versus artificial
- Beyond species typical/statistical norm
 - Bear in mind “reversion to the mean”
- Changes structure or function of the human body

What is it?

- Improving mind, body, ability
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Incremental Enhancements	Radical Enhancements
represent a change of <i>degree</i> in the expansion of human power or in the development of technology	envision a change of <i>state</i> regarding human capabilities or the purpose of technology
involve technologies which are <i>external</i> to the body and which add to it	integrate technology with biology <i>within</i> our bodies

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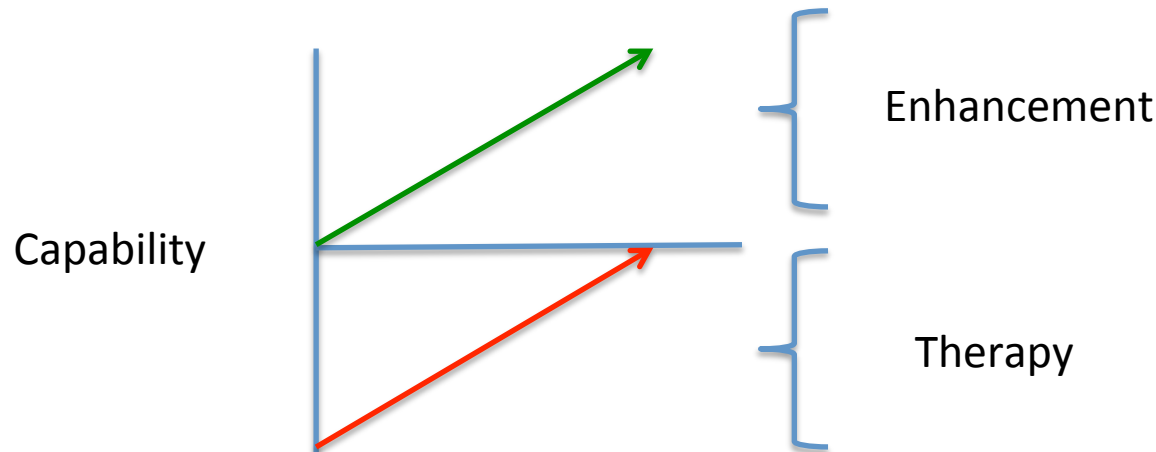
can be either reversible or irreversible	introduce <i>permanent</i> and irreversible change
generally assume a distinction between interventions that arise from therapeutic contexts and those that serve enhancement purposes	are dedicated to refashioning human beings and as such go beyond therapeutic interests; some would deny any inherent distinction

Internal versus External

- External – “always on” performance aids
- Internal
 - Intimate connections
 - Changes notion of personal identity

Therapy versus enhancement

- Eyeglasses versus binoculars
- Steroids
 - Muscular dystrophy versus athletics
- Ritalin
 - ADHD versus study aid



Set against those assumptions is a common sense notion that there is a difference between doing something because someone is ill, to make them 'better', and taking a healthy person and 'improving' them. Compassion and the desire to address human suffering provide a strong ethical justification for the former. The same is not immediately true of the latter. In various places an ethical distinction is made between interventions which would be justified under particular medical circumstances but would otherwise not be. Thus the European Convention on

Therapy versus enhancement

- Vaccination
 - Not attempting to right a shortcoming
 - So, is it an enhancement?
 - Assists in public welfare
- Head injury treatment
 - High IQ versus “normal” person
- Soldier use of stimulants and anti-depressants
- Unfair advantage?
- Lack of autonomy?



Context dependent

Contexts

- Extremes are uninteresting
 - All enhancements morally objectionable
 - All are unproblematic
- Strict equality not morally required?
 - Range of natural variation
 - John Rawls' Theory of Justice
 - Equality of opportunity

Neuroscience

- Biometrics
 - Biofeedback
 - fNIR
- Neuro-modulation
 - External
 - Internal
- Neuro-stimulation
- Neural prosthetics
- Neural control

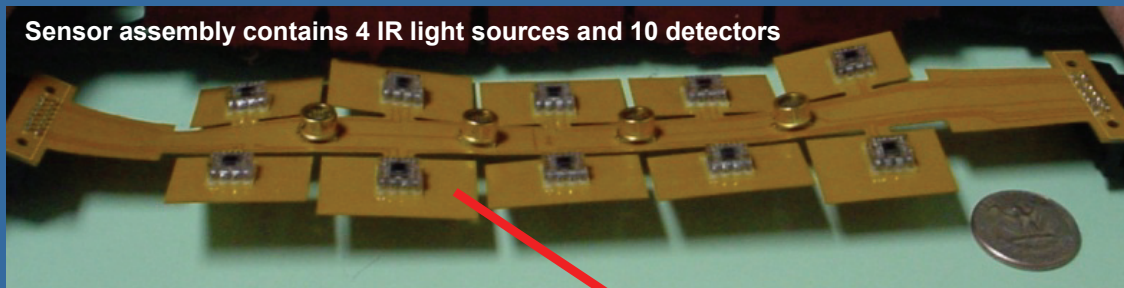


fNIR - Overview of the system

Head Piece



Sensor assembly contains 4 IR light sources and 10 detectors



Operator's Monitor





fNIR APPLICATION AREAS

- Human Performance Assessment
- Depth of Anesthesia Monitoring
- Pain Assessment
- Brain Computer Interface
- Virtual Reality
- Neurorehabilitation
- Autism
- Credibility Assessment (lie detection)

Cognitive Enhancement

- Ritalin, Beta-blockers, hallucinogens, O2 enhancers
- TMS (Transcranial Magnetic stimulation)
- Neural Implants - DARPA
 - REMIND – Restorative Memory Integration Neural Device
 - REPAIR - Reorganization and Plasticity to Accelerate Injury Recovery
- DARPA NIA – Neuroscience for Intelligence Analysis
- DARPA CT2WS – Cognitive Technology Threat Warning System

REMIND

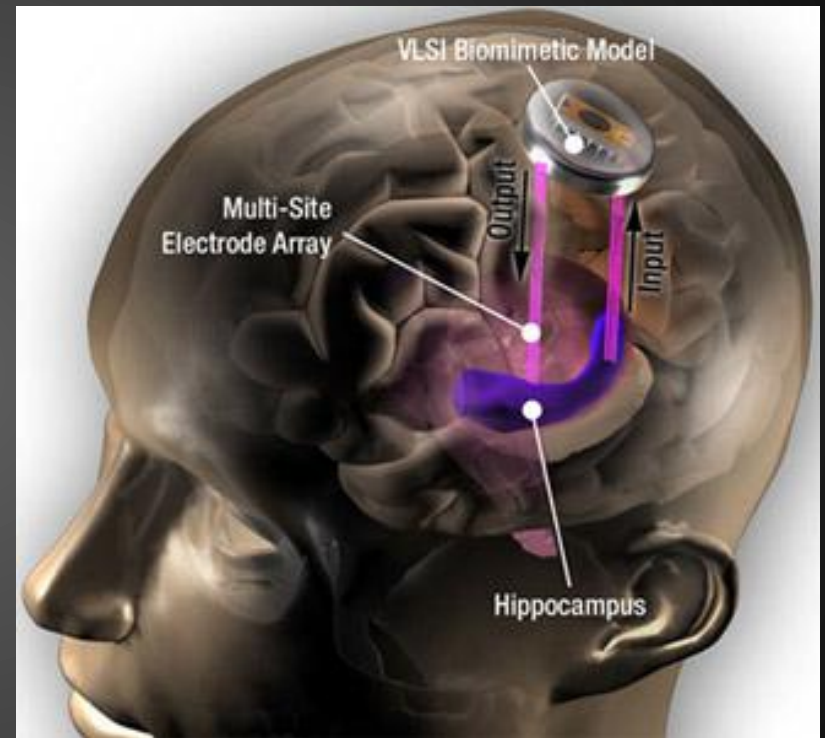
- REMIND (Restorative Encoding Memory Integration Neural Device) is a neural prosthesis, designed to mimic the hippocampus.
- Funded by DARPA, this \$16.8 million dollar project is aimed at helping soldiers recover from memory loss resulting from head trauma.
- Frequently, damage results in the inability to form long term memories, preventing returning soldiers from effectively retaining information- about their family, events, or skills for a new job.

How it Works

- The device is a tiny computer chip connected directly to brain through multi electrode array.
- Information that is normally sent by the brain to the hippocampus is instead sent through the chip.
- The device processes the inputs and converts the signals, similarly to the way the hippocampus operates.
- The information is then sent through another multi-electrode array that connects with the output neurons of the hippocampus, which sends the information to the appropriate memory-retaining areas of the brain.

Current Trials

- Currently, the technology is nowhere near sophisticated enough to mimic the human hippocampus exactly.
- The project recently moved on to development for rhesus monkeys, which is projected to take at least 3 years.
- However, the project saw huge steps in trials on rats...

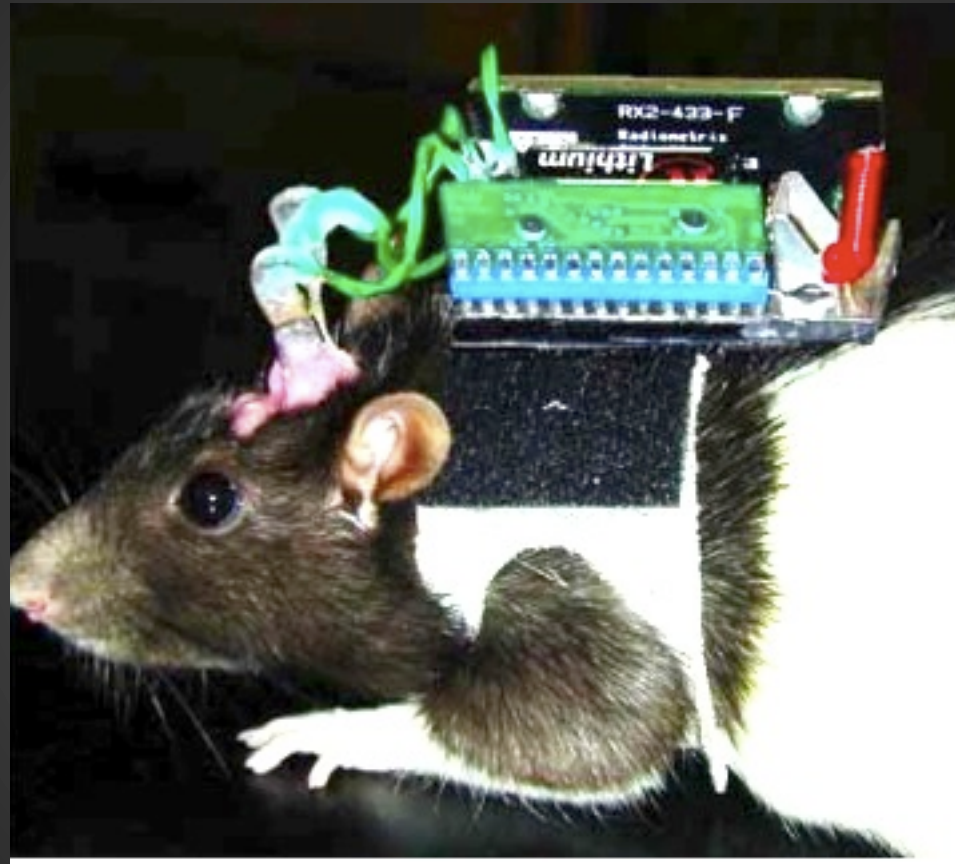


Current Trials

- Rats were trained to perform a specific task, with an average memory span of 45-60 seconds (meaning they can remember and perform a task that lasts 45-60 seconds).
- The rats brain functions were monitored, creating a recording of the processes the hippocampus carried out during the activity.
- From the recording, coding was created which simulated the hippocampus. This coding was programmed into the REMIND chip.

Current Trials

- The rats were then given a drug which reduced the capacity of the hippocampus, simulating brain damage.
- The control group of rats were then only able to retain 10-15 seconds of the same activity during training.
- With the REMIND chip implanted, rats were trained to complete the task again. Functions improved in almost every case, with most rats returning to “almost normal” conditions.



Future Directions

- Applying the technology to humans
- More precise surgery procedures- speculation that the varying degrees of returned functionality is due to "misalignment" of the device during implantation.
- Combining it with a chip on the prefrontal cortex (on the primates) to further aid in memory retention.
- Using the chip as a learning device, to "download" information directly to a person's long term memory

DARPA “REPAIR” Project

- High fidelity model of neural function
- Programming implantable computer to stimulate neuron function
- From the request for proposals:
 - “Investigators should be able to demonstrate the ability to stimulate relevant regions of the brain in such a manner that will evoke a response in the primate similar to that evoked through natural interaction with their surrounding environment... Ideally, investigators will be able to demonstrate ability of a non-human-primate to complete the task outlined in technical area one **without the use of traditional sensory inputs**”

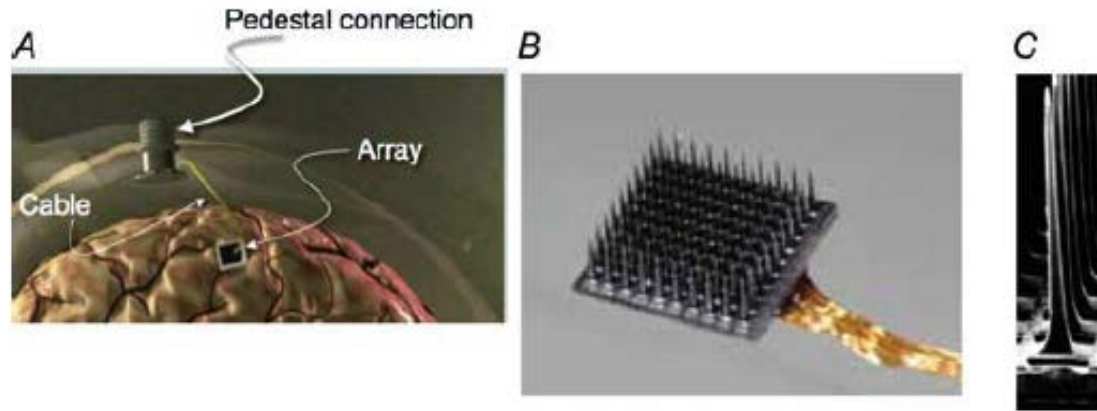


Figure 4.4: Left: A micro-electrode array shown implanted into the cortex with connections to a “feedthrough” pedestal on the skull. Center: Image of the array and wire bundle, the electrodes are spaced with $400\ \mu\text{m}$ separation. Right: Scanning electron microscope image showing the shape of the electrodes. From reference [52].

Extracted From



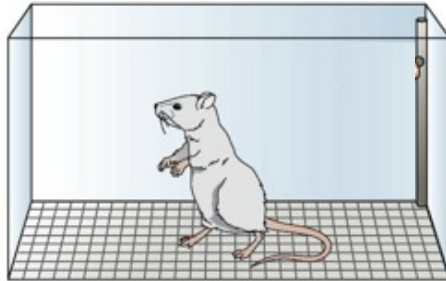
OPINION OF THE EUROPEAN GROUP ON ETHICS
IN SCIENCE AND NEW TECHNOLOGIES
TO THE EUROPEAN COMMISSION

ICT Implants for which Special Caution is Necessary

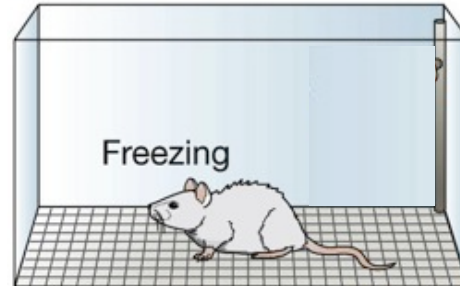
- ICT implants that cannot be removed easily.
- ICT implants that influence, determine or change psychic functions.
- ICT implants that due to their network capability could be misused in several ways for all kinds of social surveillance and manipulation, such as for instance in the case of children, or disabled persons.
- ICT implants influencing the nervous system and particularly the brain and thus human identity as a species as well as individual subjectivity and autonomy.
- Military applications.
- The distinction between therapeutic applications and enhancements (see Section 6.4.4) is not always clear.
- “Intrusive” technology that by-passes normal sensory experience.
- Implants that will influence biologically and/or culturally future generations.

OVER-EXPRESSING NMDA (NR2B) LEADS TO ENHANCED MEMORY & DOOGIE HOWSER MICE

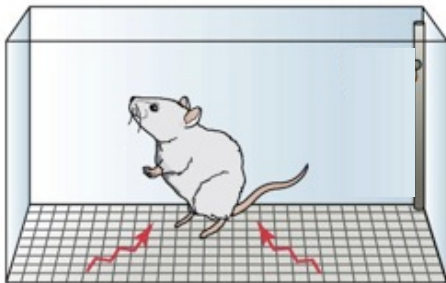
Exploration



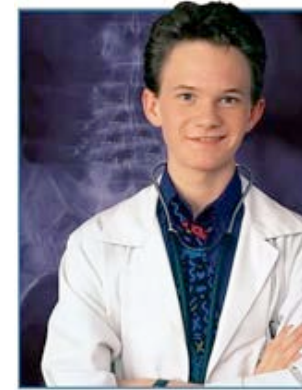
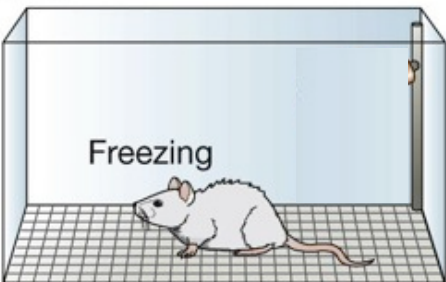
Context re-exposure



Shock



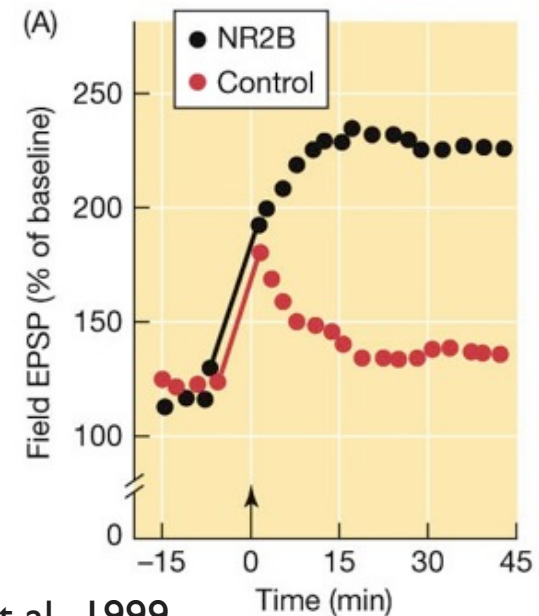
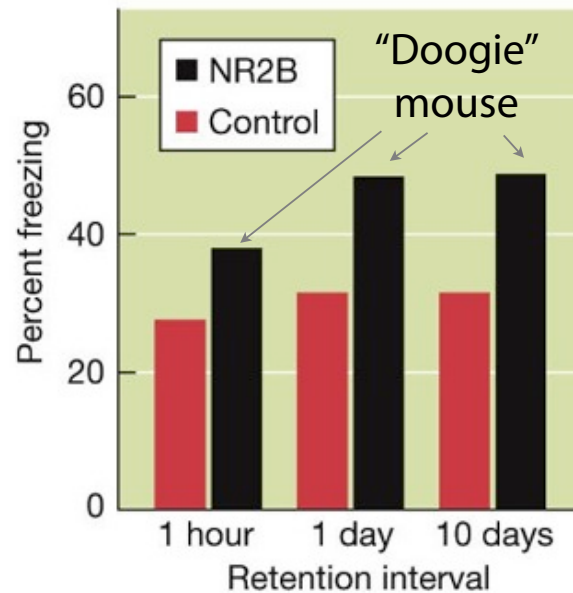
Fear



Not Joe Tsien



Joe Tsien



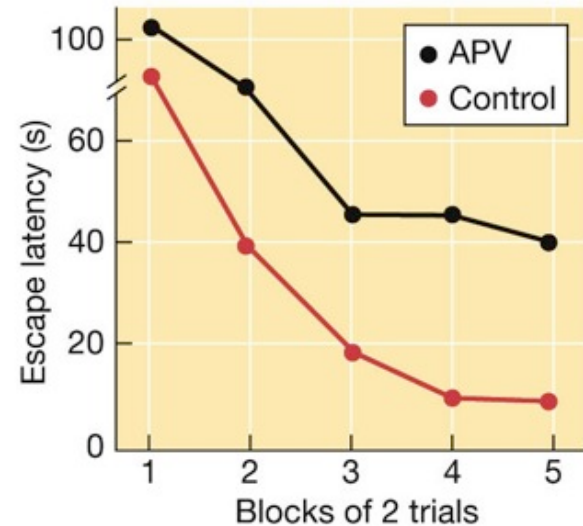
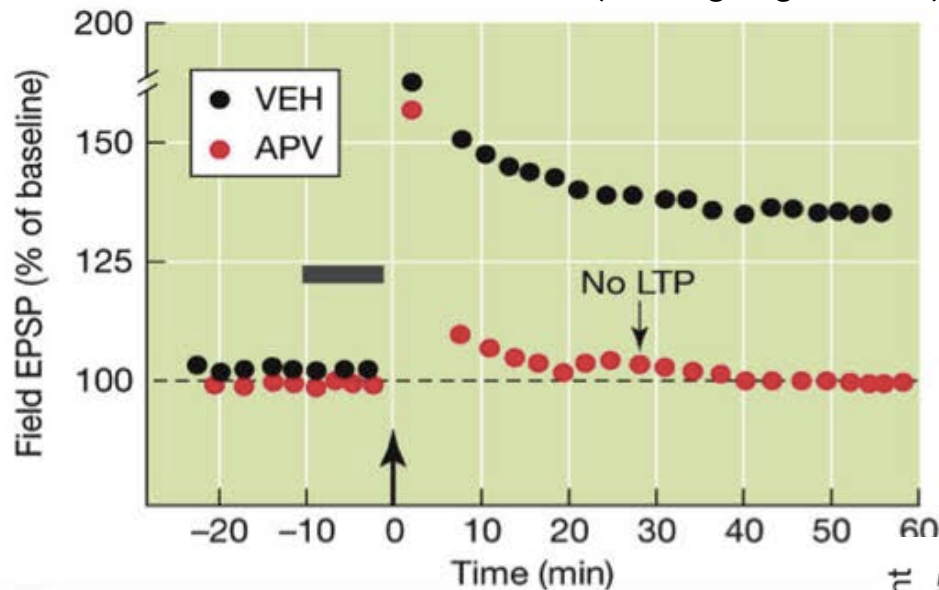
Tang et al., 1999



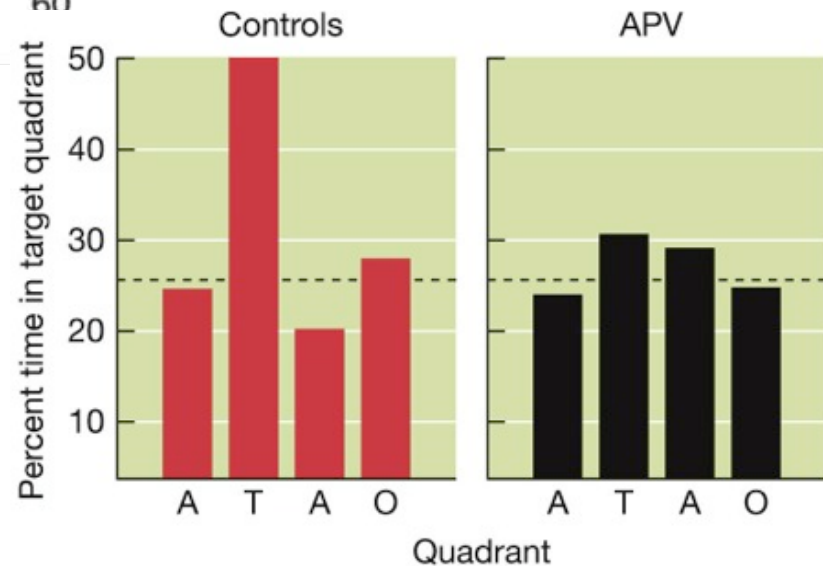
BLOCKING NMDA RECEPTORS BLOCKS LTP AND MEMORY

LTP-Long Term Potential; EPSP –Excitatory Post Synaptic Potentiation

LTP in Schaffer Collaterals (Collingridge, 1983)



Morris et al. (1986)



The trick is to erase unwanted memories, or at least take away their sting. Professor Roger Pitman, a psychiatrist at Harvard Medical School in the US, has been experimenting with a drug called propranolol, a “beta blocker” normally used to treat high blood pressure, which he believes can erase the effects of terrifying memories.

Professor Pitman has given the drug to young volunteers who have suffered extreme trauma in, for example, road accidents. Those given placebos suffered nightmares, and remained fearful of the road. When exposed to recordings describing their accidents they suffered typical stress responses – sweating, beating heart, dilated pupils. But those who had been on a course of propranolol showed no response at all. It was as though the trauma had not happened. For a soldier, memory-altering drugs such as this could mean violent combat becoming no more troubling, retrospectively, than a visit to the gym. “The problem is,” Professor Moreno says, “what else are they blocking when they do this? Do we want a generation of veterans who return without guilt?”

Michael Hanlon, The Independent

It may seem clear that if you could create a man with no scruples, who feels little pain and no fear, you would have an excellent fighting machine, but this may be a case of be careful what you wish for. We get scared for a reason – to avoid danger to ourselves and others. Fatigue may force us to rest before sustaining damaging injury. Even post-

traumatic stress disorder may have a beneficial role. Moral scruples help soldiers to act as an effective team – in battle, troops will always say they are fighting for their mates before Queen and country.

Take away the humanity of the soldiers and there is a danger that the battles and wars we fight will become inhuman as well. Most of all there is, surely, a danger that

these techniques, far from producing better soldiers, will actually produce a squad of zoned-out zombies, who will be no match for the determined, driven and highly motivated zealots of the Taliban.

Michael Hanlon, The Independent



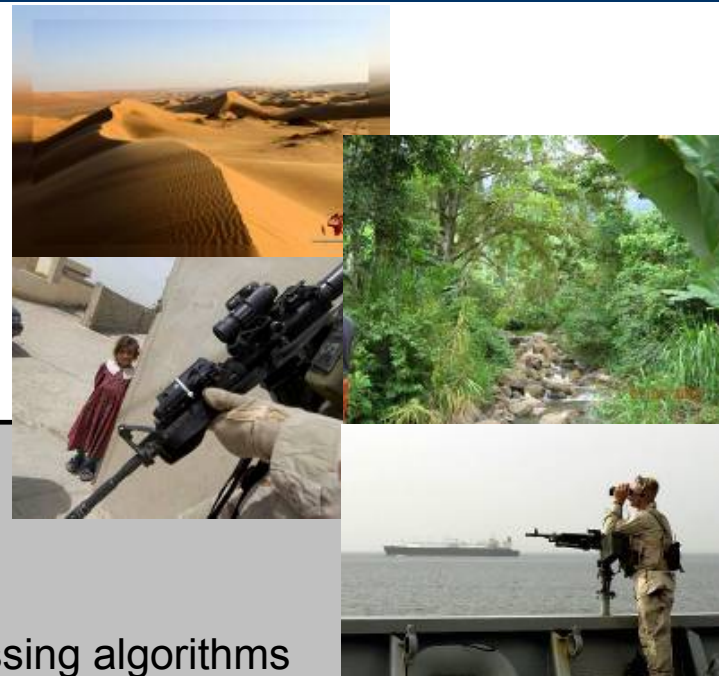
CT2WS Objectives

Detection Requirements

- Walking dismounts: 1 Km
- Stationary vehicles: 5 Km
- Moving vehicles: 10 Km
- FOV: 120°

Technologies

- Optics: Flat-field, wide-angle
- Imagers: High pixel-count, digital
- Image Algorithms: Cognitive visual processing algorithms
- Neurally-based target detection signatures → Brain in the loop
- Electronics: Ultra-low power analog-digital hybrid signal processing



Metric: $P_d \geq .98$, False Alarm Rate < 10 in less than 5 min.

NOTE

Scene Triage: **Objects of Interest** rapidly detected and presented to operator for discrimination



DEFENSE SCIENCES OFFICE

Cognitive Technology Threat Warning System

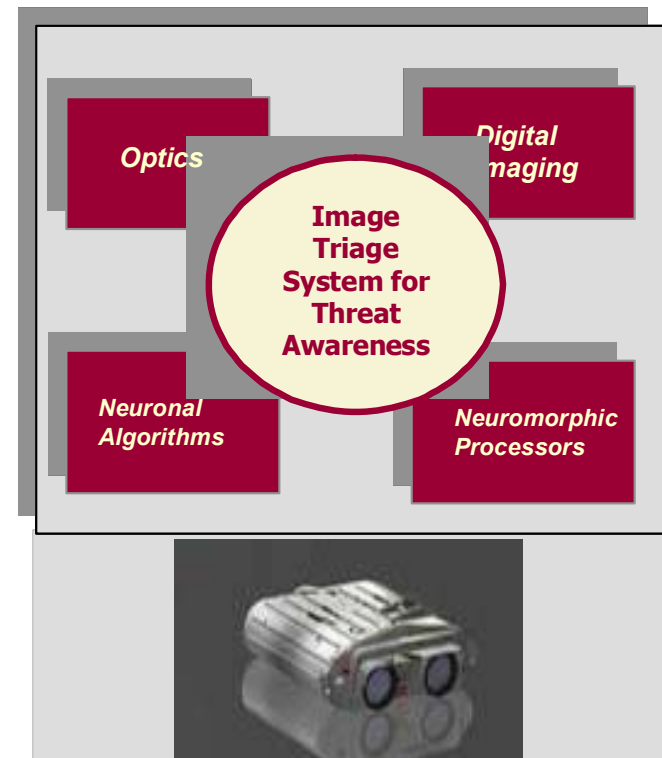
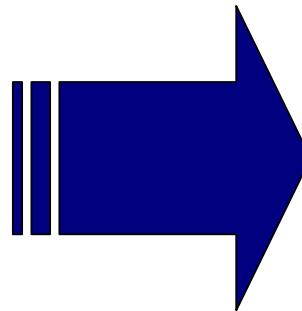
Goal: Tactical device which incorporates fusion of actual and simulated neural processing in real time to detect threats

Current: 1000-2000 m



Current (M22): 9° 22'

CT2WS: 1000-10000 m



CT2WS: 120° FOV

Genetics/Neuroscience Issues

- Manipulation/Intervention
 - Devices (do they affect “human essence”?)
 - Human/Non-human chimeras (gene transplantation)
- Privacy of genetic and neuroscience data
- Cultural Effects
 - Danger of misuse of information
 - Neuro-essentialism
- Research Ethics
 - Consent, data, phenotypes, incidental findings
- Enhancement
 - Genetics – (example: prenatal selection) long term effects
 - Neuroscience – (examples: pharmacological, implants) near term effects

Neuroethics (Greely)

- Unexpected incidental findings in neuroimaging
- How human brains make ethical decisions
- How discoveries are likely to affect society, law
 - Consequences of improved prediction
 - Competence determination
 - “Mind reading” (lying, bias, etc)
 - Enhancement

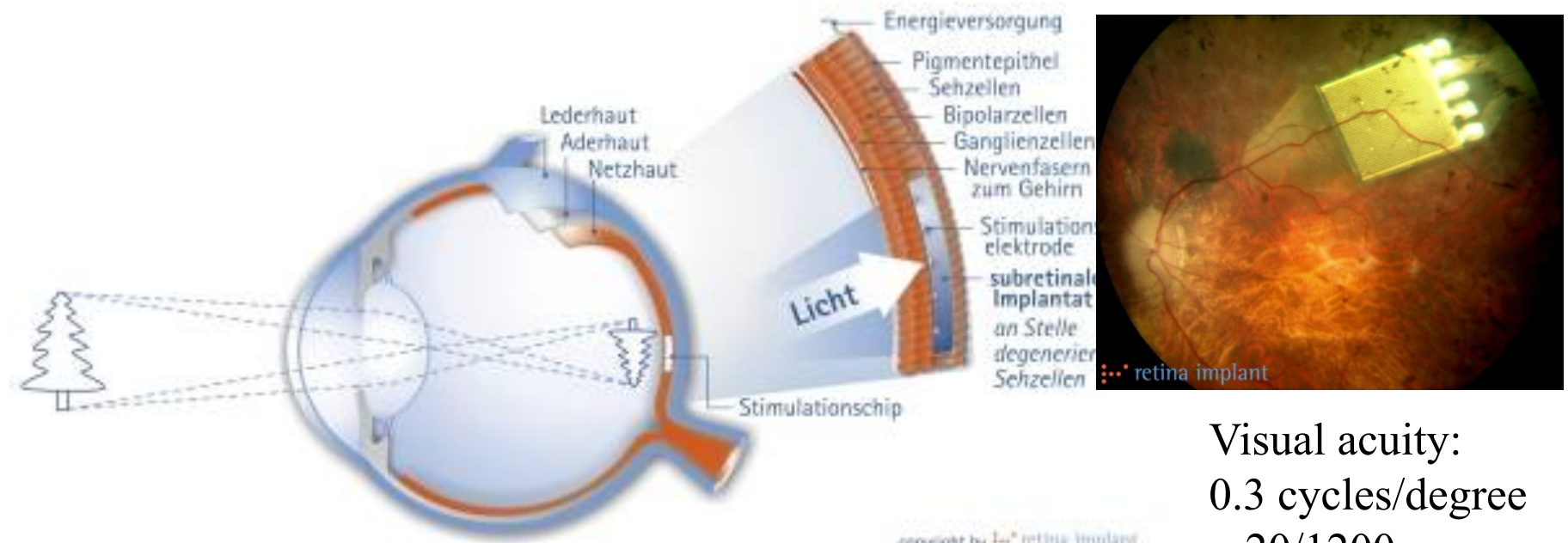
Neuroscience Issues (Loeb)

- Cost-benefit analysis
- Socioeconomic disruption
 - Cochlear implants and the “deaf culture”
- Visibility
- Privacy
- Autonomy

Physical Enhancement

- Steroids
- Cosmetic Surgery
- Prosthetics
- Cybernetics, bionic limbs
- Exoskeletons
- Lenses, visual augmentation
- DARPA – Metabolically Dominant Soldier

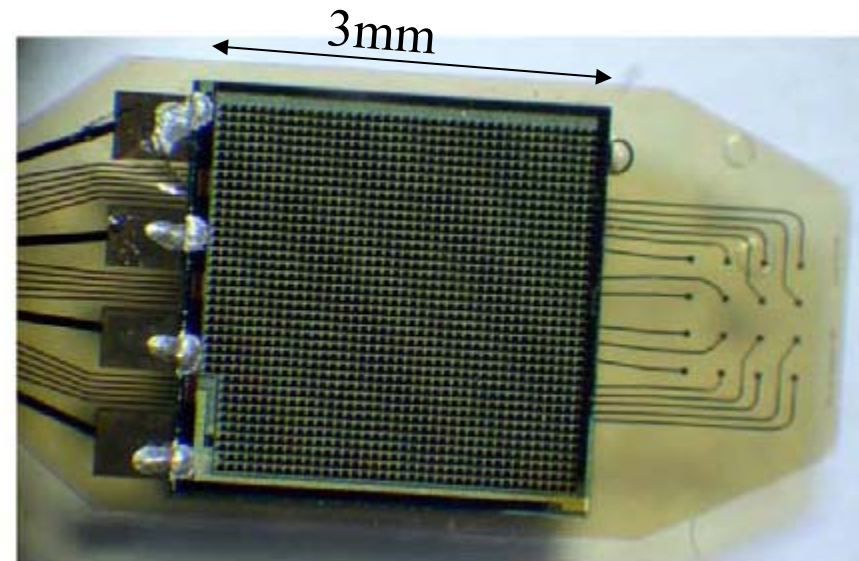
Subretinal video camera (Retina Implant AG)



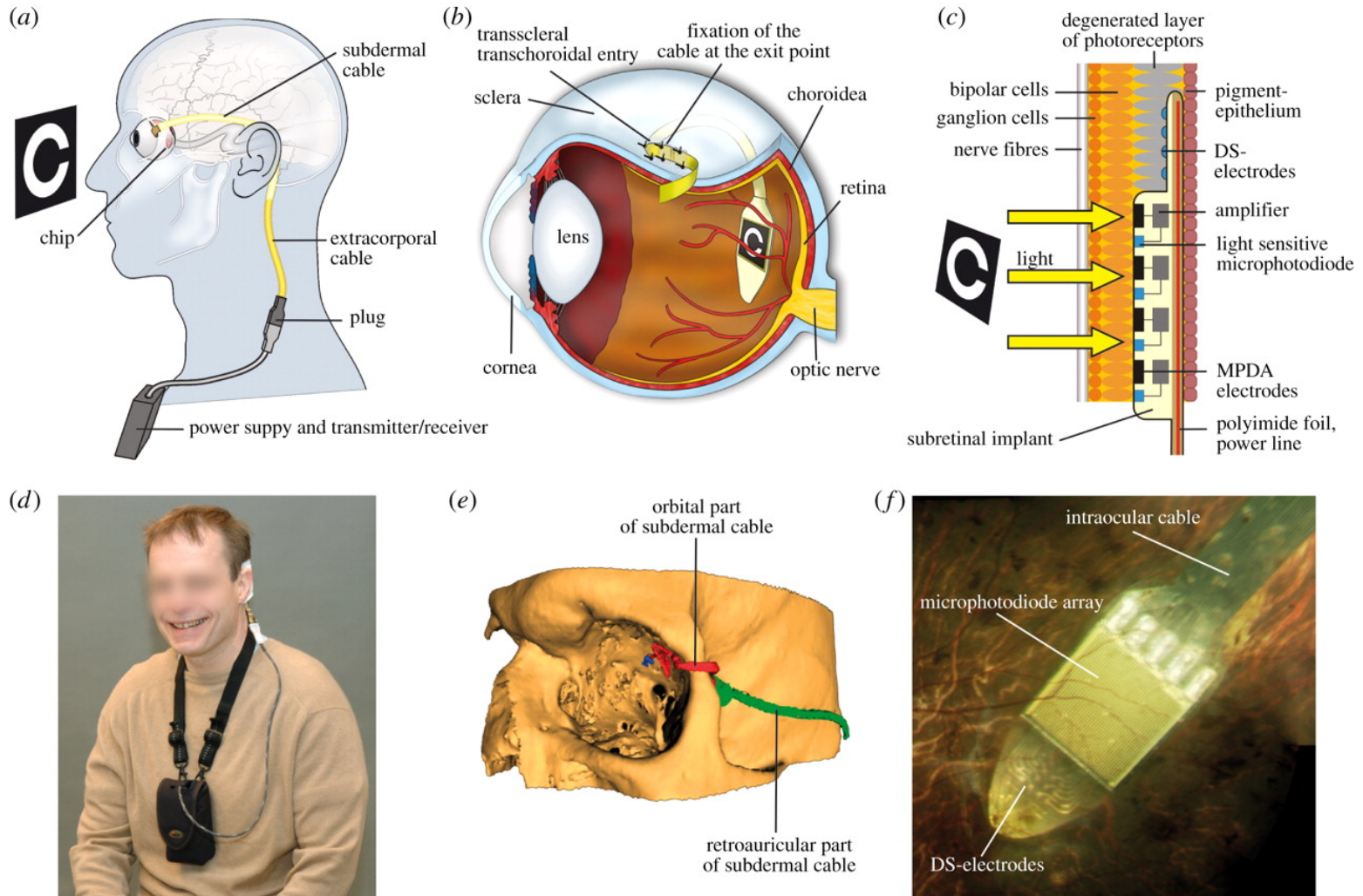
Visual acuity:
0.3 cycles/degree
~ 20/1200



1500 pixels, $70 \times 70 \mu\text{m}$ each containing a photodiode, an amplifying circuit, and a stimulation electrode. Power is provided via trans-dermal magnetic coupler placed behind the ear, like in a cochlear implant.



Retina Implant AG: Implant placement



Zrenner E et al. Proc. R. Soc. B 2011;278:1489-1497

Issues

- Freedom and Autonomy
- Fairness and Equity
- Social Disruption
- Human Dignity
- Rights and Obligations
- Policy and Law

Freedom and Autonomy

- Autonomy – do we really have it?
 - Accepted restrictions
 - Doesn't hurt anyone but me
 - Adequate informed consent?
 - Consequences for others, society
- Free Will
 - Does a person under external influence really have it?

Fairness and equity

- Enhancement (advantage) for one implies disadvantage for others
- Access for only those who can afford
- Does the enhancement benefit the society or just the individual?

Societal Disruption

- Longer lifetimes
 - Health care, resource demands, food, water, shelter, population disruptions
- Adaptation to different lifestyles
- Superhuman or extra-human abilities
- Different species
 - Genetic experimentation

Human dignity

- What does it mean to be human?
 - Mortality
 - Fallibility
 - Emotions of our own
- Pursuit of the “good life”
 - What comprises it?
 - What would be the importance of personal effort?

Rights and Obligations

- A right to be enhanced?
- Obligation to be enhanced?
 - Pilots
 - Soldiers
- Children
 - Right to be protected
- Guard against an “enhancement race”

Policy and Law

- Limits on the military
- Intellectual property issues
 - Example of patents for gene sequences
- A new formulation for ethics
 - Historically lags technology development

Important Considerations

- Long term consequences
 - Dependence, addiction
 - Societal pressure
 - Unintended social engineering, “a race to the bottom”
- Unanticipated usage
 - Ambiguity and uncertainty in prediction
- Altering the meaning of “human”
- Inability to calculate or even anticipate risk
- Environmental impacts

Specific Military Questions

- How safe must an enhancement be prior to deployment
- Should soldiers be able to *meaningfully* object?
- How do we weigh the risk to the individual against the military advantage accrued?

Framework Considerations

- Military enhancements cannot *a priori* be ruled out as illegal or unethical, but...
- Required
 - Legitimate purpose
 - Necessity
 - Benefits outweigh risks
 - Maintain warfighter dignity
 - Burdens minimized – reversible
 - Consent granted – understanding its limitations
 - Transparency and oversight
 - Superiors accountable

Additional Questions

- Would enhanced warfighters affect unit cohesion?
- Do the enhancements affect service commitment?
- Will the presence of enhanced soldiers negate or modify international conventions?
 - Torture?
- What will be the effect on society after soldier return?

The ethical dilemma, then, involves the question is it a good thing to make war a painless exercise akin to a video game or a week at a dude ranch? Is there some value to the warrior's code which is lost when the stakes are no longer high? Can we enhance the biological body to a point which is inconsistent with the definition of what it means to be human? And does this make any difference? In addition, issues of inequality are raised. Does every new soldier get the benefits of enhancement or only those deemed worthy through some sort of medical and means testing? Who gets to be an iron man, enhanced to the point of complete protection while others must continue to endure the vagaries of the battlefield? What of the intersection between these new iron men and civil society? If all new soldiers can be equally smart, equally brave, equally fit, and equally competent, what purpose will exist for the hierarchical nature of the institution, with its paternalism and emphasis on leadership? On what basis will authority rest? For civil authorities who must ponder their use of these new soldiers, will it be easier to start wars and continue the projection of force in the knowledge that there will be no body bags, minimal suffering, and long-term consequences for the body politic? Will this phenomenon continue to widen the gap between those who order the projection of force and those who accomplish it?¹¹²

Additional Interesting Readings

- The Case Against Perfection, Michael Sandel, Harvard, 2009
- The Price of Perfection, Maxwell Mehlman, Johns Hopkins, 2009
- Wondergenes, Maxwell, Indiana University, 2003